The importance of Evaluation for Early Warnings

Description

Faye works as a Senior Scientist in the Weather Impacts team at the Met Office. In this blog post she tells us about early warning systems and why robust evaluation processes are an important consideration to ensure effective early warning of severe weather.

Importance of Evaluation for Early Warnings.

I work within the Met Office Weather Impacts Team which develops processes and tools to support early warning systems. Experts in their field, some of my colleagues have even written a book on the subject of early warnings! While I would highly recommend that everyone interested reads this comprehensive work, I would like to highlight another particularly critical aspect of early warning systems – their evaluation

What are early warnings?

In essence, early warnings are systems that warn of impending hazards, allowing people to take action to reduce the societal and economic impact of natural hazards. While this may sound like a straightforward endeavour, effective early warning systems require a co-ordinated interdisciplinary approach spanning a wide range of physical and social sciences (Figure 1). Recognising the importance of early warnings in reducing the impacts and losses resulting from natural hazards, the United Nations has a 'Early Warnings for All' initiative, with the aim of ensuring that every person on Earth is protected by an early warning system by 2027.

Disaster risk knowledge
Systematically collect data and undertake risk assessments
Are the hazards and the vulnerabilities well known by the communities?
What are the patterns and trends in these factors?
Are risk maps and data widely available?
Detection, observations, monitoring, analysis and forecasting of hazards
Develop hazard monitoring and early warning services
Are the right parameters being monitored?
Is there a sound scientific basis for making forecasts?
Can accurate and timely warnings be generated?
Preparedness and response capabilities
Build national and community response capabilities
Are response plans up to date and tested?
Are local capacities and knowledge made use of?
Are people preapred and ready to react to warnings?
Warning dissemination and communication
Communicate risk information and early warnings
Do warnings reach all of those at risk?
Are the risks and warnings understood?
Is the warning information clear and usable?

Figure 1. The four components of an early warning system taken from the WMO early warnings for all website.

The Met Office is contributing to this effort, providing early warnings through the National Severe

Weather Warning Service when there is a risk of impacts resulting from severe weather (rain, thunderstorms, wind, snow, lightning, ice, fog, and now extreme heat).

Additionally, through knowledge sharing and partnerships (for example the Weather and Climate Science for Service Partnership Programme) the Met Office is helping nations globally to implement their own early warning systems. It is expected that climate change will increase the intensity, frequency, and duration of extreme weather events. Providing people with access to timely and accurate early warnings is therefore an important part of ensuring our resilience to extreme weather and adapting to climate change.

Image of flooded road. Image: Shutterstock

How can we demonstrate that early warnings are effective?

There has been a shift in the types of early warning systems used for weather hazards, from threshold-based warnings to impact-based warnings. This shift is often referred to as moving from warning 'what the weather will be, to what the weather will do'. While this evolution in warnings intuitively makes sense, providing people with more specific and relevant information on how weather may affect them is likely a good thing, the added benefits of adopting impact-based forecasts and warnings have not yet been fully measured.

Recently the World Meteorological Organization released 'Guidelines on Multi-hazard Impact-based Forecast and Warning Services'. These guidelines highlight the need to demonstrate the value of impact-based forecasts and warnings. One way to demonstrate the value of impact-based forecasts and early warnings is to develop a comprehensive evaluation strategy to assess any warnings that are issued. Evaluation of warnings can demonstrate value by quantifying the improvement of impact-based warnings over traditional weather forecasts. Additionally, evaluation can be used to measure improvement over time as warning systems are updated and refined.

How are early warnings currently evaluated?

There are many ways of evaluating warnings. Two commonly used approaches are subjective evaluation and objective evaluation. These two approaches go hand in hand, and both are necessary to fully demonstrate the value of warnings.

Subjective evaluation assesses the performance of warnings using qualitative approaches such as case studies, focus groups and expert discussion panels. Subjective evaluation allows for a deeper understanding of the accuracy of any warnings and can be used to interrogate different aspects of warning performance. Subjective evaluation is routinely conducted by the Met Office for all amber and red warnings that are issued, to determine if the warnings provided good guidance. This evaluation approach provides detailed feedback and understanding of how well each warning forecast the timing, location, and severity of impacts observed.

Objective evaluation relies on the use of standardised scores and such approaches are commonly used to verify traditional weather forecasts. Recent work by researchers at the Met Office has started to explore how objective evaluation can be used to evaluate impact-based forecasts and warnings. Objective evaluation is particularly useful when evaluating impact models and can be used to measure any improvements to model performance as they are refined and developed.

Social science studies investigating the reach of warnings and how warnings lead to action are also important to fully understand the value of warnings and how they can be improved upon. Focus groups, interviews and questionnaires can provide valuable insights into how well warnings are received, perceived, and ultimately acted upon. For example, according to post-event research conducted by the Met Office, 97% of those in the red warning area for July's heat were aware of the warning and 91% felt that the warning was useful.

Image of sunshine and cloud. Image: Shutterstock

What do we need to evaluate warnings?

In order to evaluate if impact-based forecasts can accurately warn of impacts from severe weather we

need to have data against which forecasts can be assessed. Moving from traditional threshold-based warnings to impact-based warnings has required us to obtain data not only on what the weather did, but also data on what impacts the weather caused. Both objective and subjective evaluation approaches require us to compare what impacts were forecast against the impacts that were observed.

There are many sources of impact observations that can be used, including reports from companies, agencies and organisations, news articles and even social media. Recent work by researchers at the University of Exeter has highlighted how social media can be used to identify impactful weather. Additionally, crowd-sourced initiatives can help to provide the impact observations required to evaluate impact-based forecasts and warnings, for example the Met Office Weather Observation Website, which allows users to submit observations of impacts.

Future challenges and opportunities for evaluation of early warnings.

While many observations of impacts are available, they are rarely created for the purpose of evaluating warnings. As such, much effort is required to collect, analyse, and format impact observations to use in evaluation. Current research is demonstrating how pulling together observations from many sources is important in order to develop robust and well-rounded observations of impacts that suit the needs of warning evaluation. Development of systems and processes that can identify, format, and compile observations automatically is an area of active research within the Met Office and beyond.

A significant challenge when considering warning evaluation using observations of impacts is how to account for mitigating actions that were taken because of a warning? The overarching goal of issuing warnings is to provide people with information so that they can take actions to stay safe and thrive. Hopefully this will result in fewer impacts being observed. This poses a challenge for evaluation approaches that compare predicted impacts against observed impacts, as it is difficult to identify if the lack of observed impacts was due to an incorrect warning, or if it was because people took protective action. Collecting information on actions that were taken, in addition to impacts that were observed, may help us to address this challenge.

Just as the creation of early warning systems requires a co-ordinated interdisciplinary approach, so too does the evaluation of early warning systems. Luckily for me this means that I get to work with a diverse group of incredibly talented people both within the Met Office and with external academic and international partners. Although many challenges remain for the evaluation of early warnings, I'm confident that working together we can start to better quantify the value that early warning systems provide.

Date Created
November 2022

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Mild October with interludes of rain

Description

More than half of the UK’s ten warmest Octobers on record have occurred since the year 2000, as October 2022 continues this year’s theme of being warmer than average.

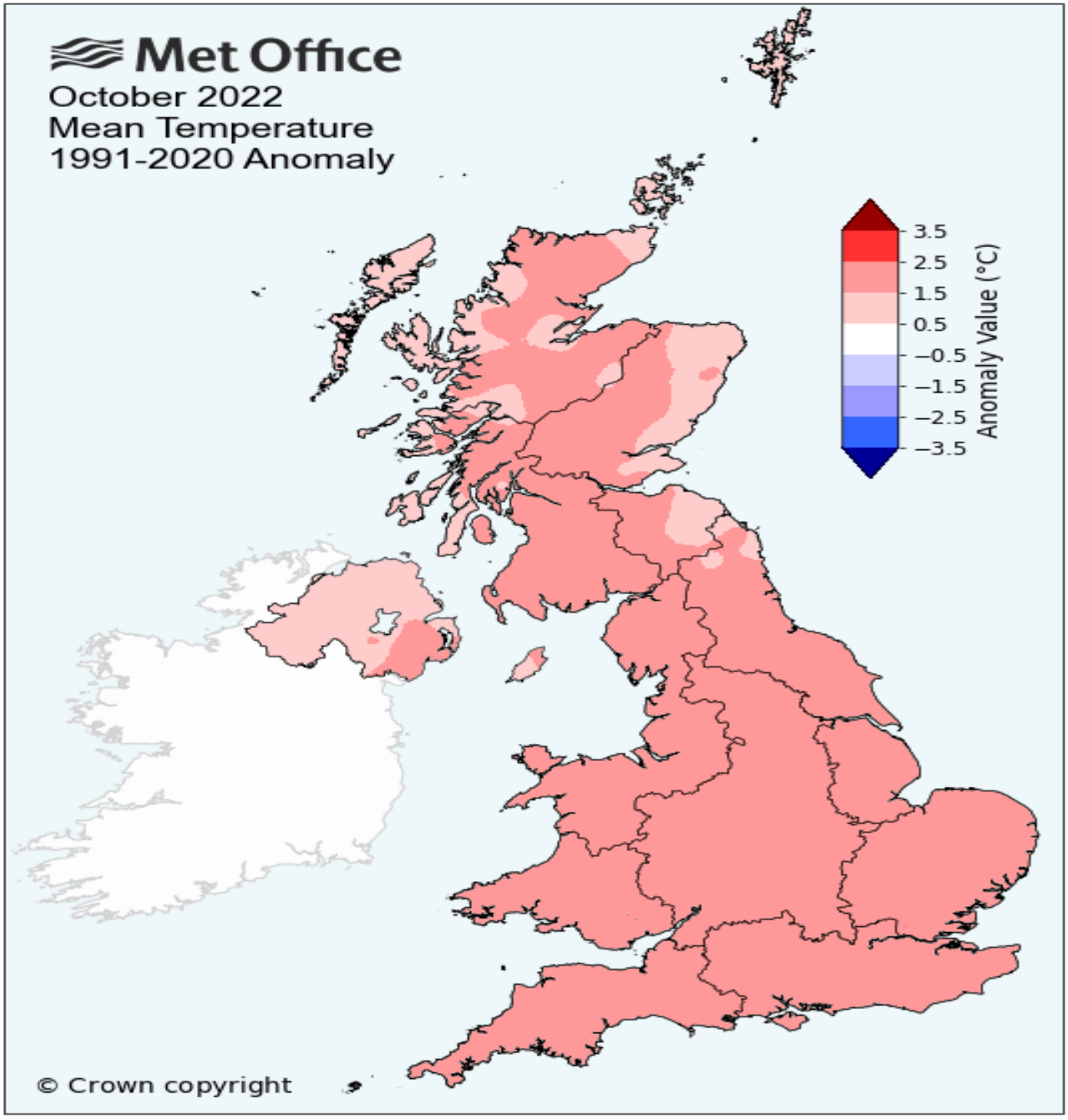
Met Office
October 2022 statistics
The seventh warmest October on record
Year so far is warmest on record
October's rain makes little dent in year's dryness
*Provisional Met Office data

According to provisional Met Office statistics, the average mean temperature for October 2022 was 11.5°C, with a particularly warm conclusion helping the month to become the seventh warmest October in a series which goes back to 1884.

The statistics mean that six of the ten warmest Octobers on record for the UK have occurred since the turn of the century, as the influence of human-induced climate change can be seen across long-term recorded data.

In addition, average maximum and minimum temperatures for the UK for October were well above average and entered at equal-sixth and equal-fifth in their respective records.

Average maximum temperatures were particularly high across central southern England and East Anglia. England had its equal-fourth warmest October on record, with 12.6°C. Wales had its equal-fifth warmest October by the same measurement with 12.0°C, while Scotland had its equal-eighth warmest, with 9.7°C.



October 2022 mean temperature map

Michael Kendon, of the National Climate Information Centre, said: “October was already proving to be

a warm month but there were some very mild conditions late in the month with 22.9°C at Kew Gardens on 29 October.

“The position of the jet stream late in the month helped shift temperature up, as a southwesterly airflow invited warm air over Europe on to UK shores. It should also be noted that France and Spain also recorded temperatures well above their average for the time of year, which was partly responsible for the warmth of the air we were bringing in late in the month.

“What has been particularly unusual about this October is the persistent above average temperatures – particularly across the southern half of the UK. Maximum temperatures have been above average on every day of the month – always reaching the mid-teens.”

The mild October continues 2022’s run of every month so far this year being warmer than average. The first ten months of 2022 are the warmest on record, tracking ahead of 2014’s warmest year on record for the UK. Temperature statistics will continue to be monitored particularly closely through November and December.

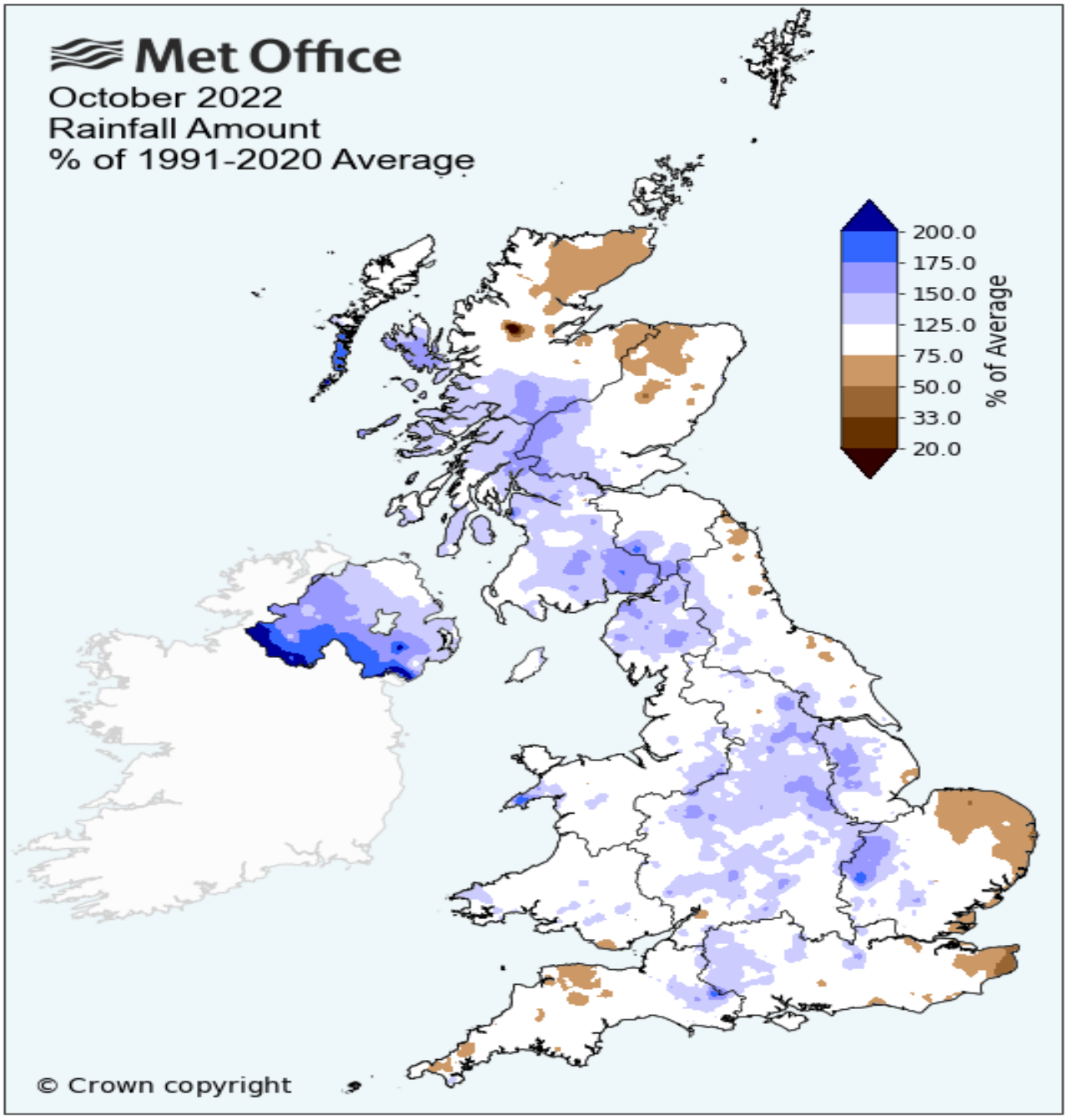
Near-average rain for many, but still a dry year

Slightly above average rainfall for the UK in October did little to impact the dry year so far for some regions.

In 2022 so far, East Anglia has seen just 52% (328mm) of its average rainfall for the whole year. You’d expect this percentage to be at 83% at the conclusion of October. This means counties including Norfolk, Suffolk, Kent and East Sussex have received only around half their annual rainfall, in some places less, with only two months of the year to go.

At the conclusion of October, you’d expect rainfall amounts to be at 83% of their long-term average for the complete year. For the UK, it’s currently at 67% (780mm), but for England it’s at only 60% (523mm), and also at only 60% for Wales (881mm).

October’s rain itself was slightly above average for the UK, with Northern Ireland exceeding its long-term average rainfall by more than 50%. The UK’s figure of 141mm was 15% more than average. More granular figures were fairly unremarkable, though Northern Ireland’s 176mm was 54% more than its average, while Scotland had 16% more rainfall than average, with 196mm falling.



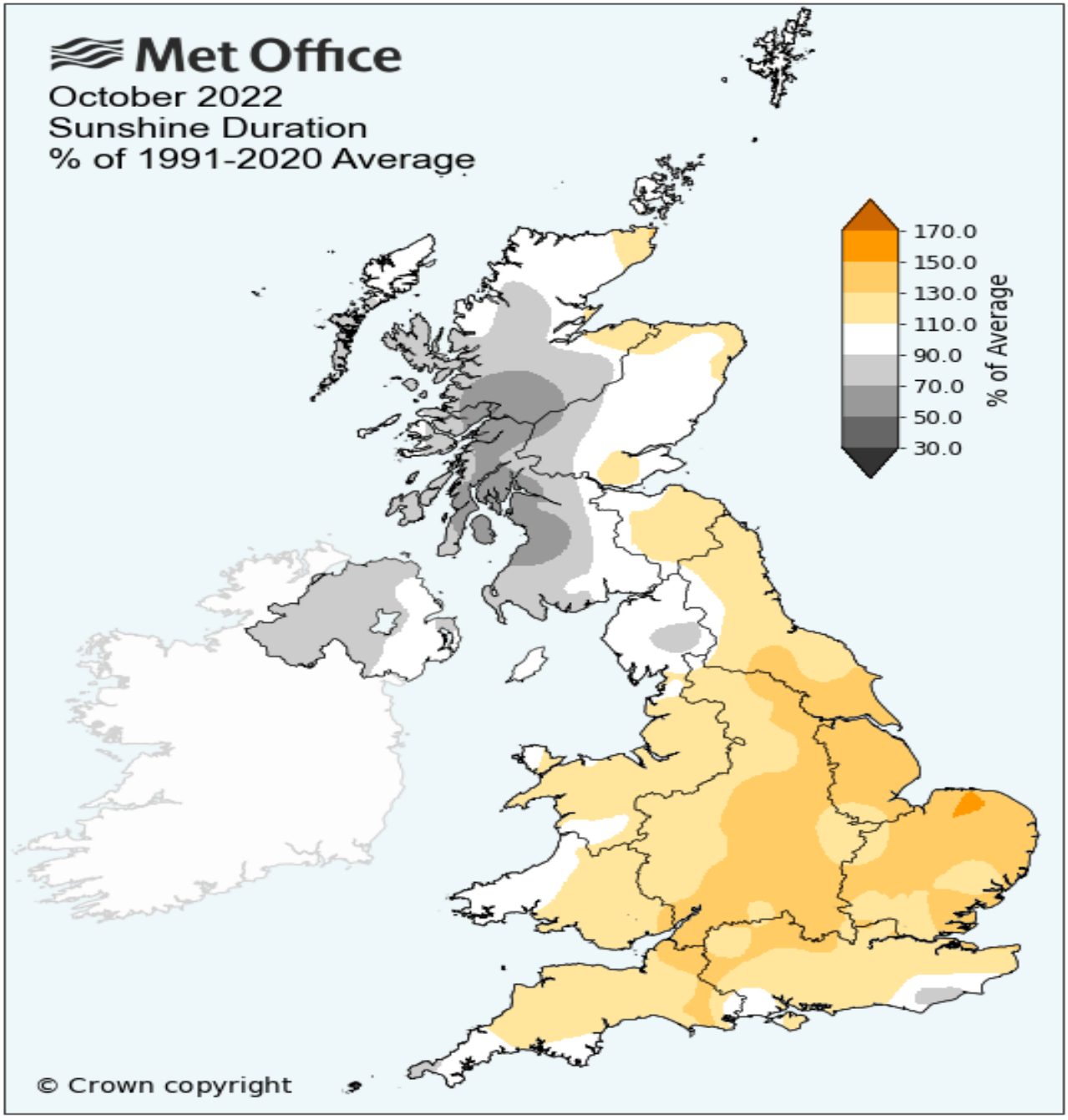
October 2022 rainfall map

Despite the near-average rain in October, this year continues to be much drier than average, especially in the south.

The Senior Director of Policy, Research and Campaigns at the Consumer Council for Water Mike Keil said: “There’s still a lot of rainfall needed to replenish our water resources after the incredibly hot and dry summer. Saving water is always a good thing to do, whatever the weather – it helps people save money, protects the environment and reduces carbon emissions.”

Sunny October for most

October was sunny for most, although Scotland and Northern Ireland were slightly duller than average.



October 2022 sunshine duration map

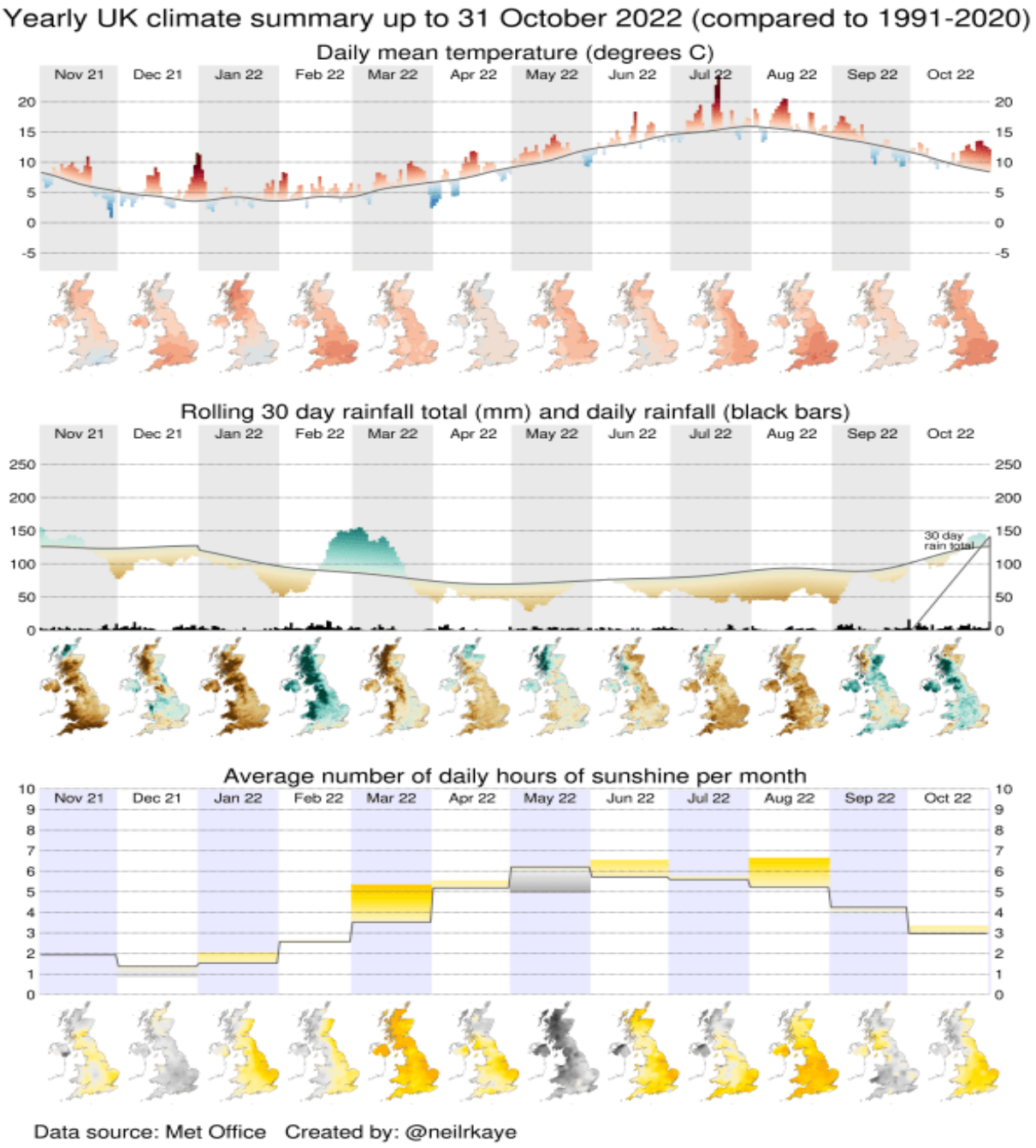
The UK saw 14% more sunshine than average, with 105 hours of sunshine in the month.

England had 129 hours of sunshine (26% more than average), Wales 104 hours (14% more than average). Conversely, Scotland had 69 hours of sunshine (7% less than average) and Northern Ireland

73 hours (14% less than average).

Provisional October 2022	Mean temp (°C)		Sunshine (hours)		Rainfall (mm)	
	Actual	Diff from avg (°C)	Actual	% of avg	Actual	% of avg
UK	11.5	1.8	104.6	114	141.4	115
England	12.6	2.0	129.0	126	99.6	110
Wales	12.0	1.9	104.2	114	175.4	111
Scotland	9.7	1.5	69.3	93	195.8	116
N Ireland	11.0	1.4	73.2	86	175.9	154

Provisional weather and climate statistics for October 2022.


Yearly UK climate summary up to 31 October 2022 (compared to 1991-2020)
Daily mean temperature (degrees C)
Nov 21
Dec 21
Jan 22
Feb 22
Mar 22
Apr 22
May 22
Jun 22
Jul 22
Aug 22
Sep 22
Oct 22
Rolling 30 day rainfall total (mm) and daily rainfall (black bars)
30 day rain total
Average number of daily hours of sunshine per month
Data source: Met Office Created by: @neilrkaye

Date Created
November 2022

Single actions on climate change can have multiple benefits

Description

When it comes to climate change the science is very clear: to restrain global warming we must rapidly cut our emissions of greenhouse gases.

But that's not all that's required. The planet has already warmed by more than a degree since the mid nineteenth century, leading to rising seas and more frequent floods, droughts and wildfires. And due to existing carbon dioxide concentrations in the atmosphere, some measure of further warming is unavoidable. For this reason, we're already having to adapt to reduce the impacts climate change can have on society.

These two strands of response to climate change are known as mitigation and adaptation. We need to mitigate to avoid the very worst potential impacts of climate change, and we need to adapt to the impacts from the climate change we're already committed to in the future.

It is increasingly recognised that there are benefits from considering actions on mitigation and adaptation together. For example, by developing sustainable infrastructure, homes may be more resilient to new climate extremes such as heat, while also being more economic to run, saving energy and preventing greenhouse gas emissions.

And the benefits don't have to be restricted to avoiding physical climate impacts. They could also positively benefit people's health, the economy, our delicate ecosystem or even our society and culture. These 'win-win' actions are known as co-benefits and they are scalable from small individual decisions, all the way to major infrastructure projects.

The University of Leeds, working with the Met Office, has developed a new tool for policymakers, academics and industry to see how single actions can have multiple benefits for people's lives and the world around them.

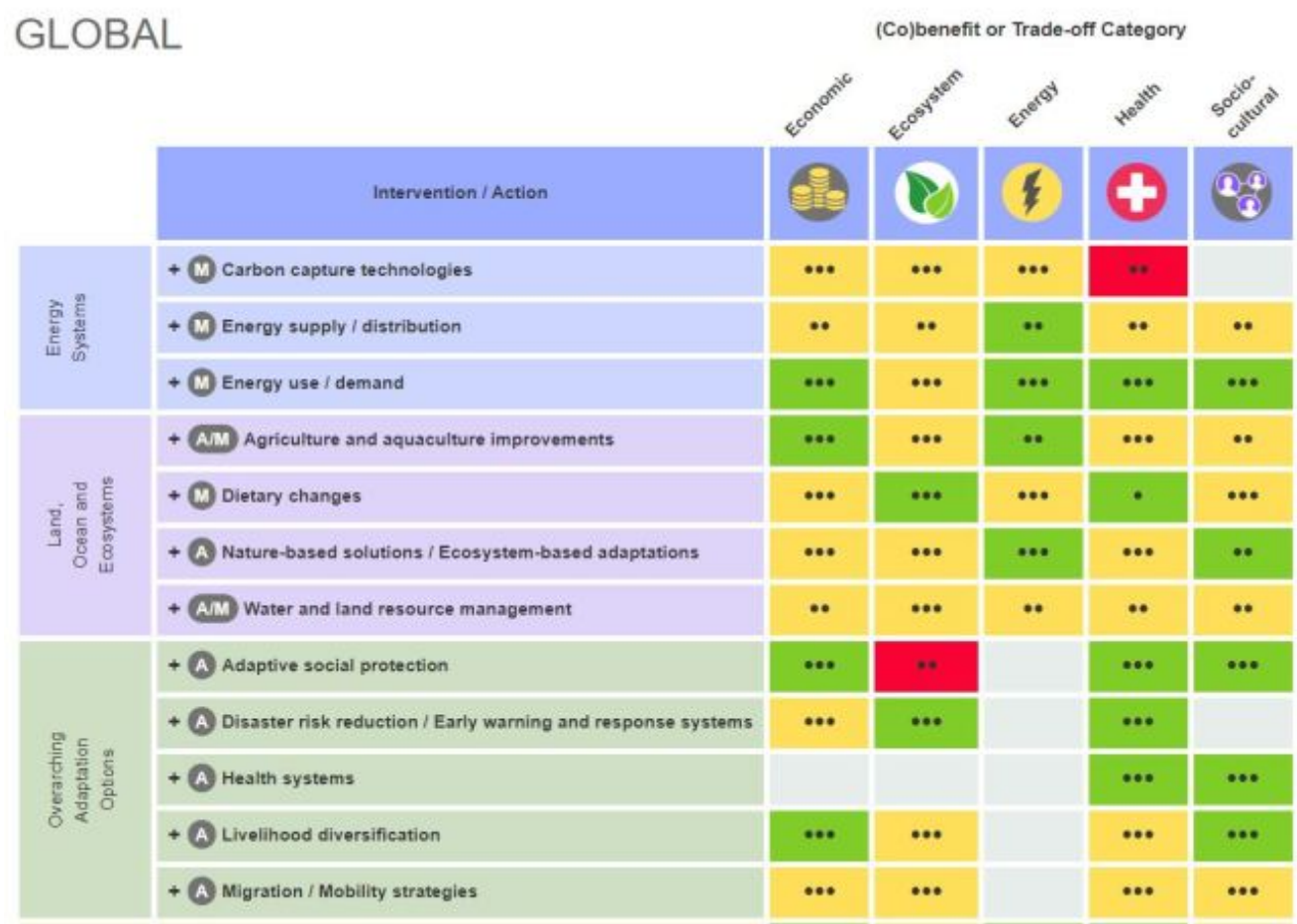


Image: Screengrab of the new co-benefits tool launched at COP27.

Launched at COP27 in Egypt , the new tool builds on existing scientific evidence in an accessible and interactive way to help people and institutions understand how different climate actions might generate benefits or trade-offs across different regions and contexts. You can watch the event at the UK Pavilion at COP27 where the tool was launched in the video below.

Within the tool the user can select the region they are interested in and easily see how a range of different actions interact with categories that they might benefit or where there could be a risk of a trade-off. By using peer-reviewed scientific evidence to populate the tool, it aims to provide policymakers, academics and industry with a simple and trustworthy method of assessing the impact and potential wider value through co-benefits of a particular course of action.

At the time of the tool launching, Government Chief Scientific Advisor, Sir Patrick Vallance, commented: “We know that immediate and sustained action is needed to prevent the most dangerous impacts of climate change. By adopting a systems approach, we can prioritise solutions that result in the greatest net benefit, both for human health and the environment”.

A particular example of co-benefits examined by the Met Office assesses how urban environments are at particular risk of climate change impacts. Analysis in City Heat Packs created by the Met Office for the UK Resilience programme shows the sorts of risks cities could expect under a warming climate through this century. Urban environments are also a good example of where these co-benefits can

really play out.

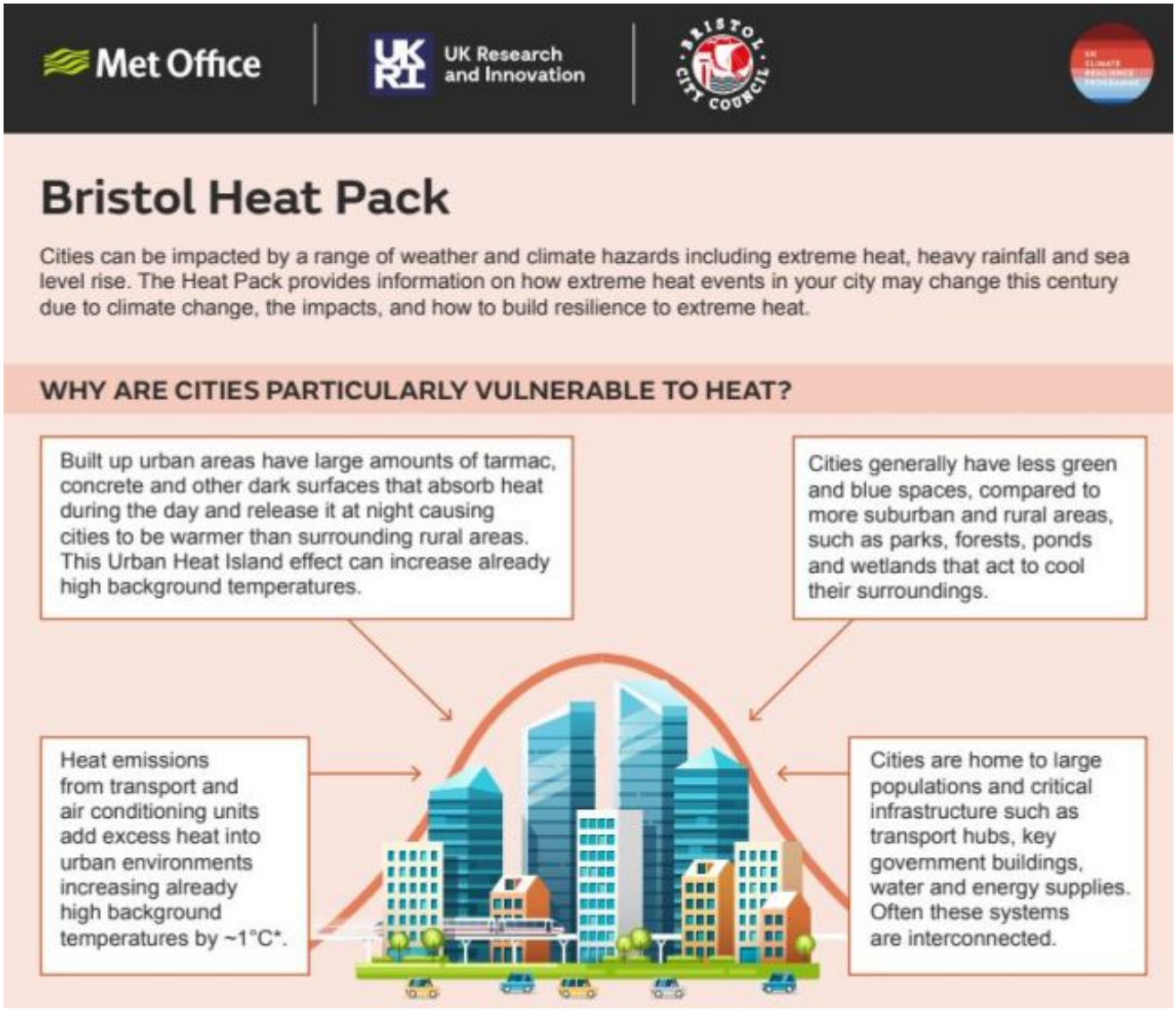

Met Office
UK Research and Innovation
Bristol City Council
Bristol Heat Pack
Cities can be impacted by a range of weather and climate hazards including extreme heat, heavy rainfall and sea level rise. The Heat Pack provides information on how extreme heat events in your city may change this century due to climate change, the impacts, and how to build resilience to extreme heat.
WHY ARE CITIES PARTICULARLY VULNERABLE TO HEAT?
Built up urban areas have large amounts of tarmac, concrete and other dark surfaces that absorb heat during the day and release it at night causing cities to be warmer than surrounding rural areas. This Urban Heat Island effect can increase already high background temperatures.
Cities generally have less green and blue spaces, compared to more suburban and rural areas, such as parks, forests, ponds and wetlands that act to cool their surroundings.
Heat emissions from transport and air conditioning units add excess heat into urban environments increasing already high background temperatures by ~1°C*.
Cities are home to large populations and critical infrastructure such as transport hubs, key government buildings, water and energy supplies. Often these systems are interconnected.

Image: A screenshot of an example section from the Bristol City Heat Pack produced by the Met Office.

For example, by adapting urban areas to include more green spaces and bodies of water, there can be benefits for ecosystems, energy use and health. Water and air quality can be improved, urban heat island effects can be limited as green spaces lower urban temperatures, and energy can be saved as less surface water travels through combined sewers and wastewater treatment plants. With reduced urban temperatures people living in towns and cities would also be at less risk of heat stress and have more outdoor spaces that are shown to improve mental health. So, by taking one action, there are multiple co-benefits to society.

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How can we respond to the dangers of extreme heat in UK cities?

Description

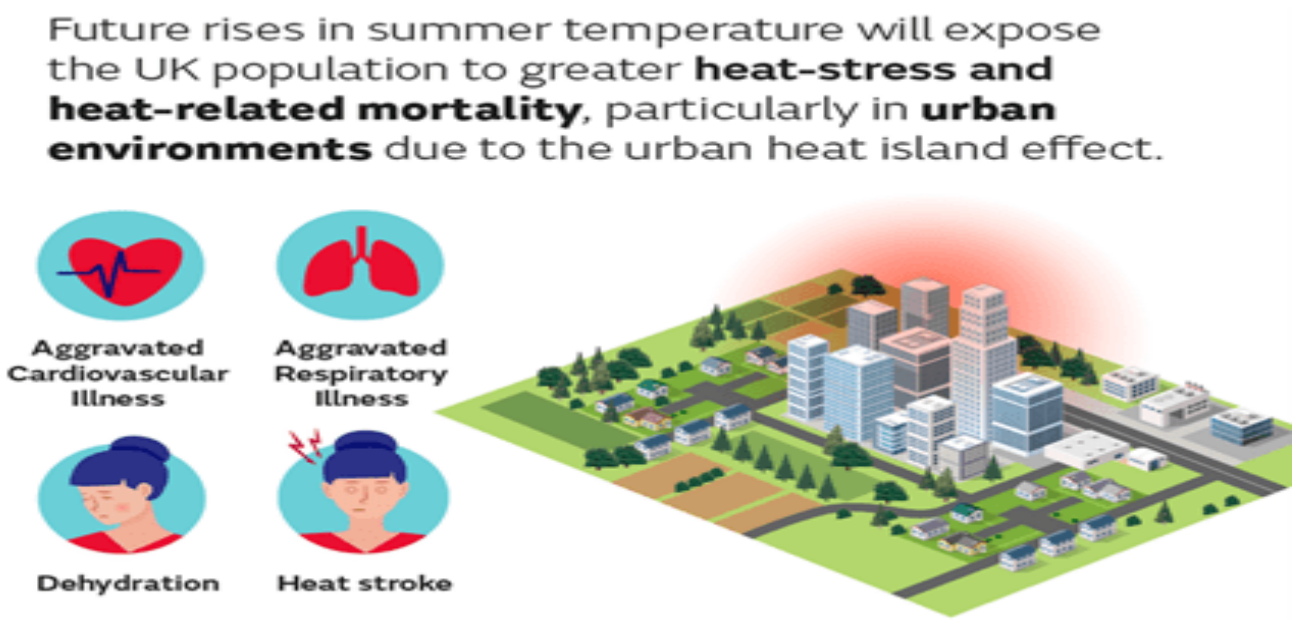
As the planet warms, we are seeing a steady increase in average global temperatures, the impacts of which we are already experiencing. Projections indicate that the UK will continue to experience increasingly warm, wet winters and hot, dry summers as a result of human-induced climate change.

Hazy sunset over London. Image: Shutterstock

One of the consequences of rising summer temperatures is an increased risk of exposure to heat stress, and inhabitants of urban environments are at particular risk of suffering from this. In this blog post, we explore why cities are particularly vulnerable to extreme heat and learn about some of the work that is being undertaken to better understand the influence that urban environments have on extreme temperatures. We'll also explore how this research can inform decision making on the ways that UK cities adapt to future climate change impacts.

What is heat stress?

Heat stress can in some cases be fatal. It occurs when the human body cannot keep itself cool and maintain a healthy temperature (37°C). Symptoms of heat stress include dizziness and headaches, and feeling faint, tired or lethargic. Higher than average temperatures bring with them an increased risk of heat stress, particularly for those people who are vulnerable, for example babies, the elderly and people with underlying health conditions.


Future rises in summer temperature will expose the UK population to greater heat-stress and heat-related mortality, particularly in urban environments due to the urban heat island effect.
Aggravated Cardiovascular Illness
Aggravated Respiratory Illness
Dehydration
Heat stroke

Graphic showing impacts on the human body from heat-stress. Image: Met Office, UKRI

Why are urban environments more vulnerable to heat? The Urban heat island (UHI) effect

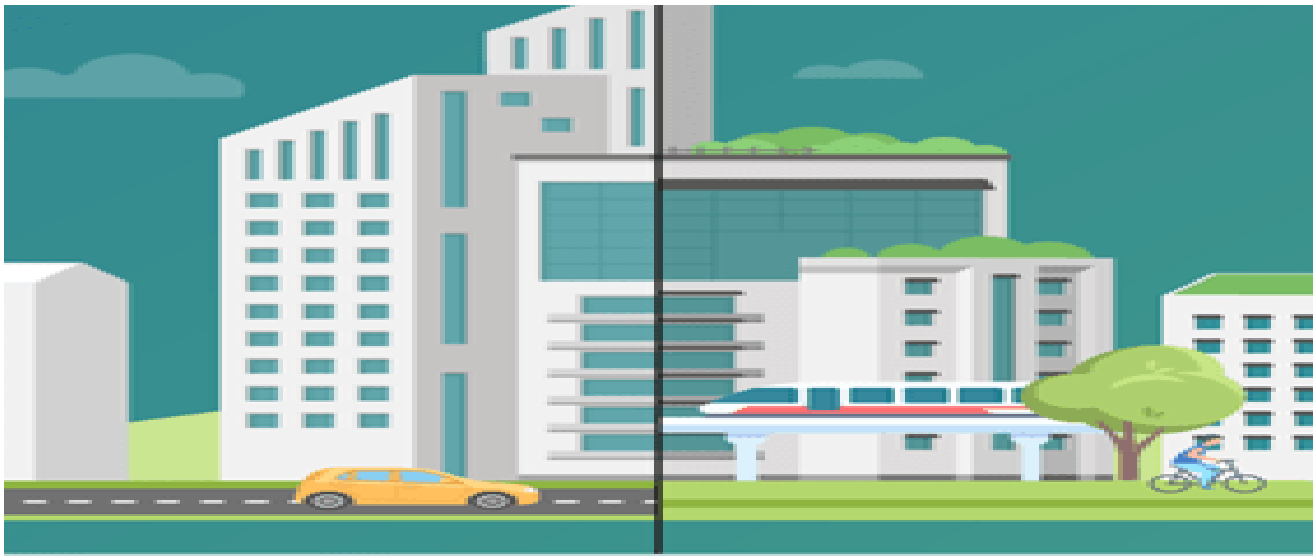
Urban inhabitants are at particular risk from heat stress due to the 'urban heat island' (UHI) effect, whereby temperatures are warmer in cities compared to surrounding rural areas. Urban heat islands are caused by a range of factors, including more absorption of heat due to the surface properties of cities, additional trapping of heat due to tall buildings, and additional heat released by human activity such as the heating/cooling of buildings.

There also tends to be less green space in cities which helps to moderate temperature through processes such as evapotranspiration. While the UHI is typically largest at night, it has important health consequences because it prevents urban inhabitants from recovering from heat during the day. This is particularly important during extreme heat events. During the European heatwave in the summer of 2003, it was estimated that 52% of heat-related deaths in the West Midlands were attributable to the urban heat island effect[1].

As global average temperatures continue to rise, the issue of the UHI effect is likely to worsen, presenting significant risks for people living in urban areas, the number of which is also expected to increase.

How can we respond to extreme heat risks?

To help mitigate the risks posed by climate change and the UHI effect, the Met Office provides climate information to health agencies and urban planners so that they can implement effective adaptation responses for urban areas. These could include increasing the number of trees and green spaces in cities, or a change to the materials and methods with which buildings are constructed. Before beginning to implement such measures however, it is important that decision makers adequately understand the nature and severity of the extreme temperatures and the areas in which they will be most severely felt.



Graphic showing urban adaptation measures. Image: Met Office, UKRI

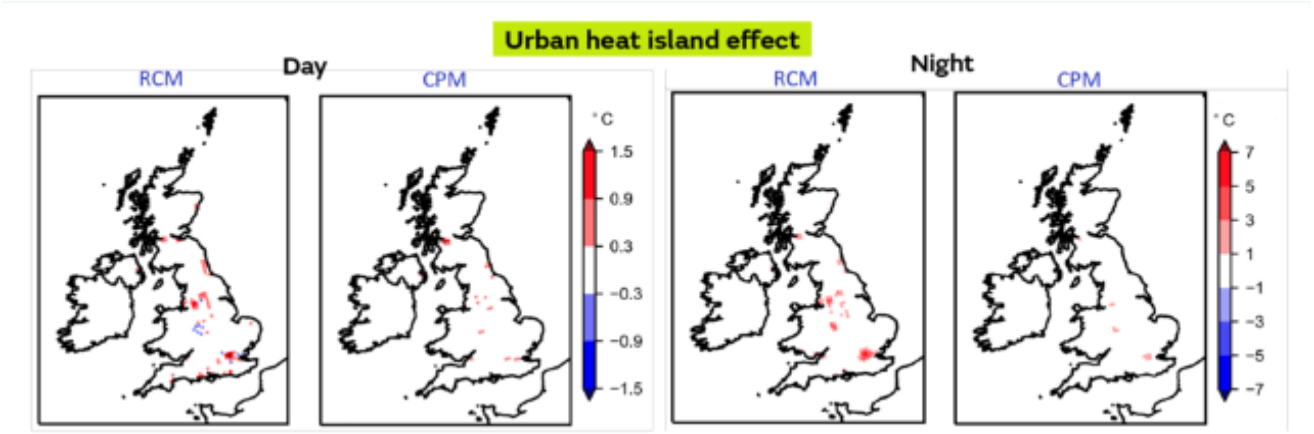
Climate research – improving understanding for resilient cities

To better understand the future exposure of urban inhabitants to heat stress, researchers use climate information produced by computer models to accurately quantify changes to the frequency and severity of temperature extremes.

In a study[2], 'Climate change over UK cities: the urban influence on extreme temperatures in the UK climate projections', led by Met Office Senior Scientist Will Keat as part of the Strategic Priorities Fund-funded UK Climate Resilience (UKCR) programme, work was undertaken to better understand the urban influence on temperature extremes in UK cities for both present day (1981-2000) and the future (2061-2080). The project used the latest UK Climate Projections (UKCP18), which include 12km resolution Regional Climate Model (RCM) simulations, and state-of-the-art convection-permitting model (CPM) simulations at a higher resolution of 2.2km, which can explicitly represent convective storms and provide improved estimates of hourly extremes.

What does this research tell us?

The study revealed significant differences in behaviour between the CPM and RCM when examining the influence of urban environments on temperature extremes.



Graphic showing the different outputs of RCM and CPM. Image: Met Office

Using the present day as a reference point, the urban influence on temperatures in the RCM was too large, leading in particular to an overestimation of the number of warm nights over urban areas compared to observations. Meanwhile, the CPM more accurately represented both day and night temperatures, and correctly captured the number of warm nights.

This better representation of present-day urban climates in the CPM is a result of both increased resolution and improved representation of the urban environment. This gives us confidence in future projections of urban temperatures and indicates that the use of CPM projections is preferable for the provision of evidence to support urban adaptation strategies.

Will Keat said: “These results highlight the importance of considering the new UKCP Local (CPM) projections to better understand future changes in urban temperatures during hot days and warm nights. Without these projections, future daytime extreme temperatures would be underestimated and night-time temperatures overestimated, which could have significant implications for urban resilience planning and public health.”

Research such as this is invaluable as it provides policy makers with improved insights into the future risk for urban areas and aids adaptation decision-making, helping build UK resilience to future changes in weather and climate variability.

To learn more about this project, visit the UK Climate Resilience Programme website.

References:

1 – Heaviside C, Vardoulakis S, Cai XM (2016) Attribution of mortality to the urban heat island during heatwaves in the west midlands, UK. Environ Health 15(1):49–59

2 – Keat et al., 2021, Climate Change over UK Cities: The Urban Influence on Extreme Temperatures in the UK Climate Projections, Climate Dynamics, Vol. 57, pp 3583–3597

Date Created

November 2022

Funding boost for earth observation sector

Description

The UK Government has this week made a significant investment in the UK's Earth Observation sector. Of a budget of up to £200m, the Met Office will receive £11.73m.

Satellite-based earth observations are essential for understanding our planet. Picture: Shutterstock

In the announcement of the package, the UK Government recognises that Earth Observation is a 'vital science and a growing industry'. Additionally, the sector supports the UK to become a science superpower and prioritises national space and Net Zero ambitions. More than half of key climate data comes from space.

Commenting on the announcement, Professor Stephen Belcher said: "The UK has a vibrant landscape of world-leading Earth Observation organisations and a well-founded reputation for excellence in the field. The Met Office welcomes the announcement as earth observations play an essential element in allowing businesses and people to make better decisions to stay safe and thrive."

The funding the Met Office receives will help support three initiatives:

- The development of satellite-enabled products to improve the UK's national weather, air quality and maritime forecasts. The information gathered in space will enhance the capability of climate models, helping the UK to increase resilience to climate risks, as well as facilitating the potential for new satellite-enabled applications potentially spawning new services and business opportunities.
- A project to support the use the rapidly-developing area of environmental digital twins – computational replicas of the earth, featuring climate, environmental and societal data. The new national capability enables the UK to blend analysis from machine learning and AI with earth observations gathered in real time to address challenges such as climate change, biodiversity loss and air quality.
- The establishment of an international training and skills exchange programme between the UK and the USA. This academy will support the development of the highly-skilled workforce necessary to advance the UK's earth observation sector into the future.

Other UK beneficiaries cited in the announcement include: the European Space Agency; the UK Space Agency; The Natural Environment Research Council; Science and Technology Facilities Council; and Innovate UK.

Date Created
November 2022

First signs of colder weather following a mild autumn

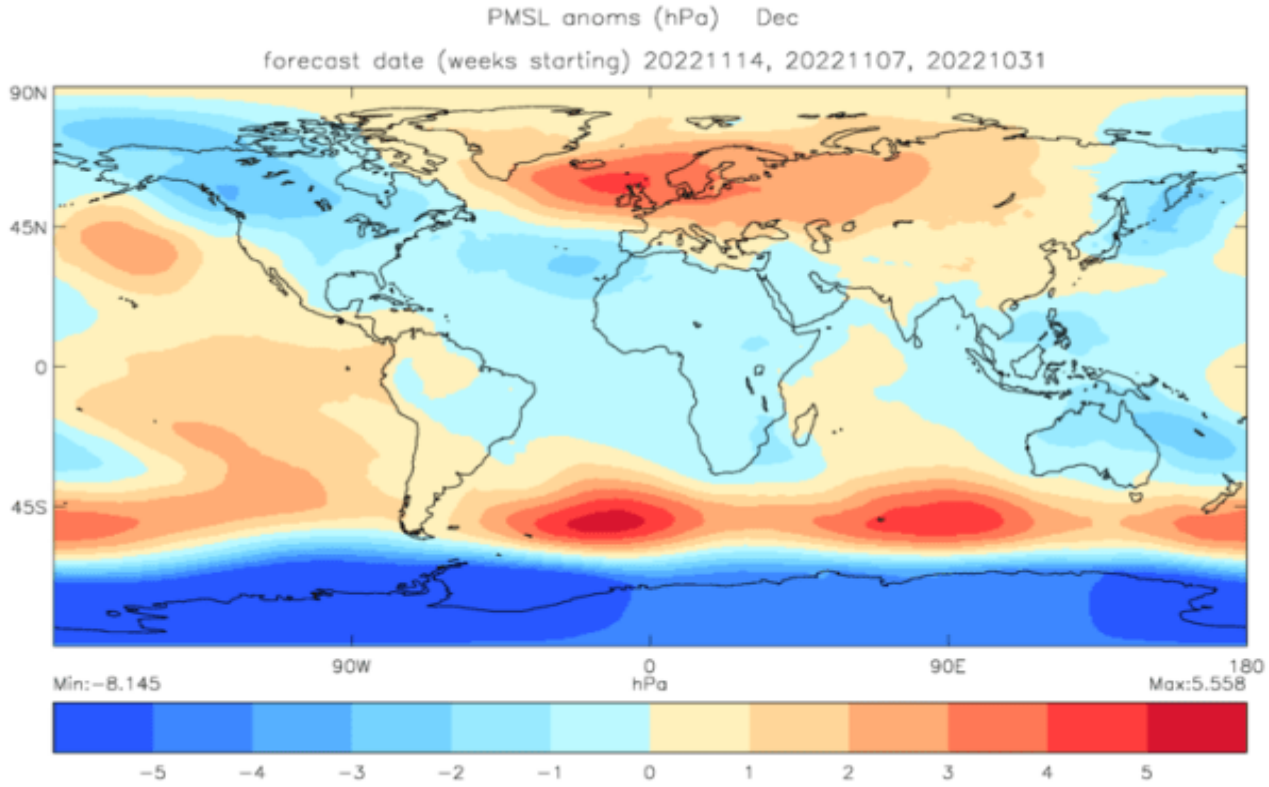
Description

Professor Adam Scaife Met Office Head of Monthly to Decadal Prediction.

Winters in the UK usually include a wide variety of weather, and this winter looks to be no exception. Autumn 2022 has been remarkable on many fronts. A warm start to September and a notable warm spell from mid-October to mid-November, means this autumn has been one of the warmest on record, with mean temperatures significantly above the 1991-2020 averaging period. Perhaps more significantly, even if we were to see average temperatures for December, then 2022 could well be the warmest year on record for the UK.

While there are indications in the long-range forecast that we could see some mild weather this winter, we are expecting a colder start. Our medium-range models are starting to indicate that high pressure will begin to dominate our region in December, increasing the potential for cold spells, although we could still see wet and windy weather at times as well as later in the winter (check our 30-day forecast).

Exact weather conditions will be dictated by just where the high pressure settles over the Atlantic and the UK. While this type of outlook cannot identify day-to-day weather there is relatively good agreement that weather patterns in **December** will become more settled than we have seen in November. High pressure prevents mild, moist air from flowing to the UK from the Atlantic Ocean increasing the potential for lower temperatures, with some threat of snow and ice mainly in northern areas and a reduction in the chance of early winter storms compared to normal.



Predicted pressure anomaly (difference from normal) for December 2022 in hectoPascals (hPa)

As we head further through the winter the picture changes and current forecasts suggest that the risk of high pressure decreases in **February**, allowing more unsettled conditions to develop, with wet, windy, and mild spells more likely. This means that the chances of a very cold winter, comparable to 2009/10, are still low this winter. Nevertheless, although it is not predicted in the near future, there is still a risk of a Sudden Stratospheric Warming occurring later this winter. If this happens, it could increase the risk of wintry weather and could lead to a further cold spell for the UK and northern Europe.

Professor Scaife added: “Over the years the Met Office has played an important role in supporting Government and business to interpret long-range forecast probabilities to help them make risk-based decisions. The long-range outlook cannot identify the weather on a given day or even week, so it is not very useful if you want to know if we will see snow on Christmas Day. Nevertheless, certain industries and sectors of society do find this type of information helpful. Especially those who can benefit from insight about the coming season, such as whether it is more likely to be wetter or drier, warmer or colder, windier or calmer than average.

An indication of the likelihood of conditions that impact transport, energy, health etc. can allow planners in these sectors to prepare accordingly. As we go through the winter months, we will be able to give more detail of potential winter hazards and will issue updated forecasts and warnings each month and as and when needed.

Winter Weather Drivers

The science in this area is at the cutting edge of meteorology and the Met Office is one of the leading lights in scientific research in the area. However, even with ‘perfect’ prediction systems and ‘perfect’ meteorological observations, the fundamental chaotic nature of the atmosphere will still limit the skill of these predictions. Although, the science does not allow for specific detail on the amount of rain or snow over the coming months or exactly when severe weather may occur, long-range forecasts can provide useful information on the possible conditions averaged over the UK for a season as a whole.

These predictions are driven by global weather patterns and their influence on the UK increases through late autumn and into winter. The global weather patterns that may influence our weather over the next three months are:

La Nina, a cooling of the tropical Pacific Ocean, which promotes the development of high pressure in the Atlantic in early winter, increasing the chance of winds from the north or northwest early in the winter and increasing the chance of westerly winds later in the winter.

- The Madden Julian Oscillation, an eastward progression of large regions of tropical rainfall from over the Indian to the Pacific Ocean, increasing the chance of blocking patterns in early December and potential spells of colder UK weather early in winter.
- The Quasi-Biennial Oscillation (QBO), a regular variation of the winds that blow high above the equator. The QBO is currently in a westerly phase which increasing the chance of westerly winds from the Atlantic.

Even if these influences suggest an overall higher-than-usual chance of a cold start to winter, this will not rule out having wet and windy spells, or even a mild winter overall. These scenarios would just be less likely based on the information available at the time the forecast is made. It is important to keep up to date with our regular monthly updates to the long-range outlook.

You can check the long range forecast and daily weather forecast on our website. You can also follow us on Twitter and Facebook, as well as on our mobile app which is available for iPhone from the App store and for Android from the Google Play store. Our three month outlooks are updated each month. Keep track of current weather warnings on the weather warning page.

Date Created
November 2022

Vigil mission a ‘huge step forward’ for space weather forecasting

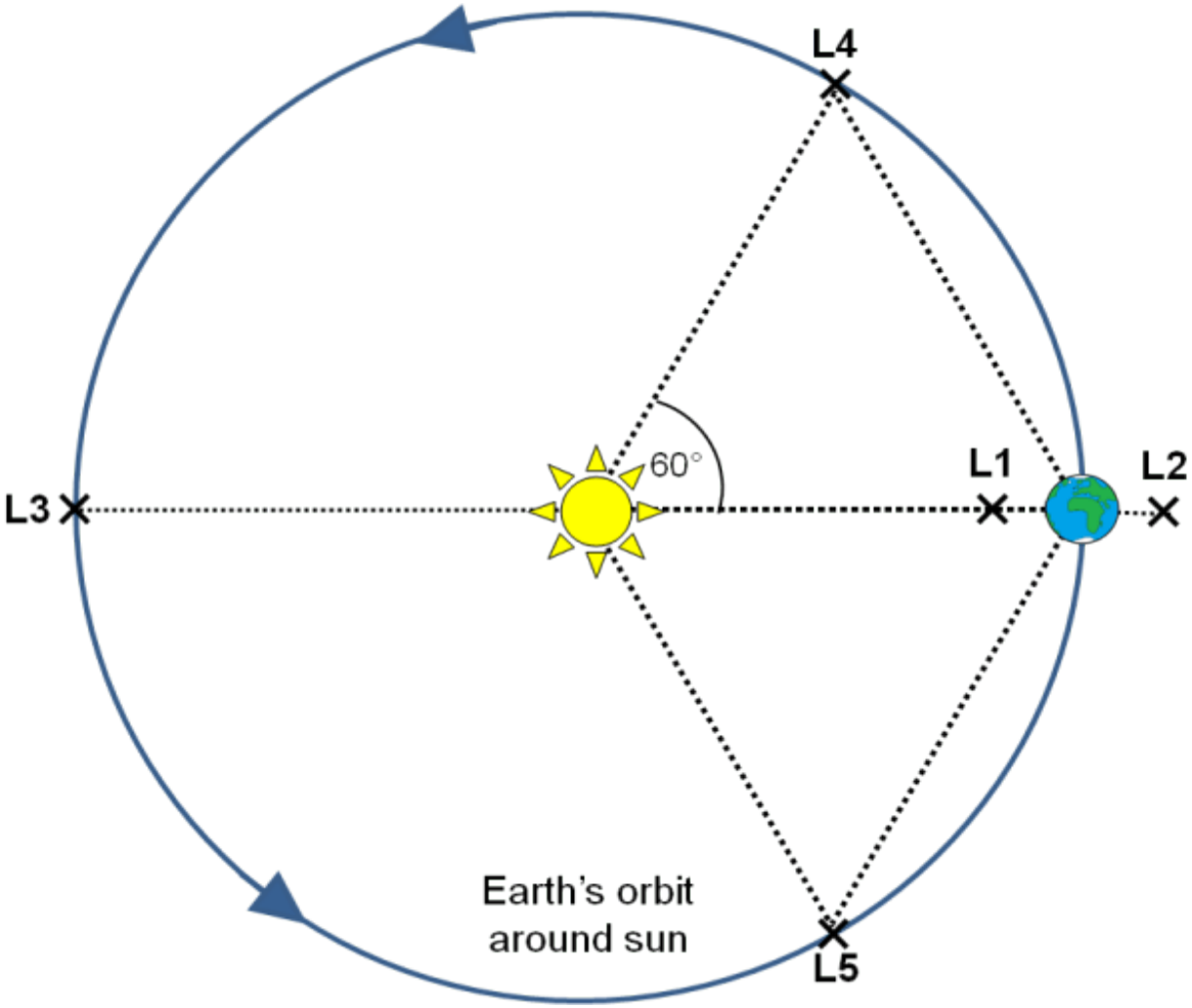
Description

Confirmation of the long-awaited Vigil mission is a ‘huge step forward’ for space weather forecasting according to the Met Office’s Mark Gibbs.

The confirmation was made as part of a UK government announcement committing £1.84billion for a range of important space programmes at this year’s European Space Agency Council of Minister meeting, held in Paris.

For space weather forecasting, the Vigil mission will greatly improve space weather forecasting capabilities, with the Met Office Space Weather Operations Centre one of a number of centres that will benefit from the new satellite.

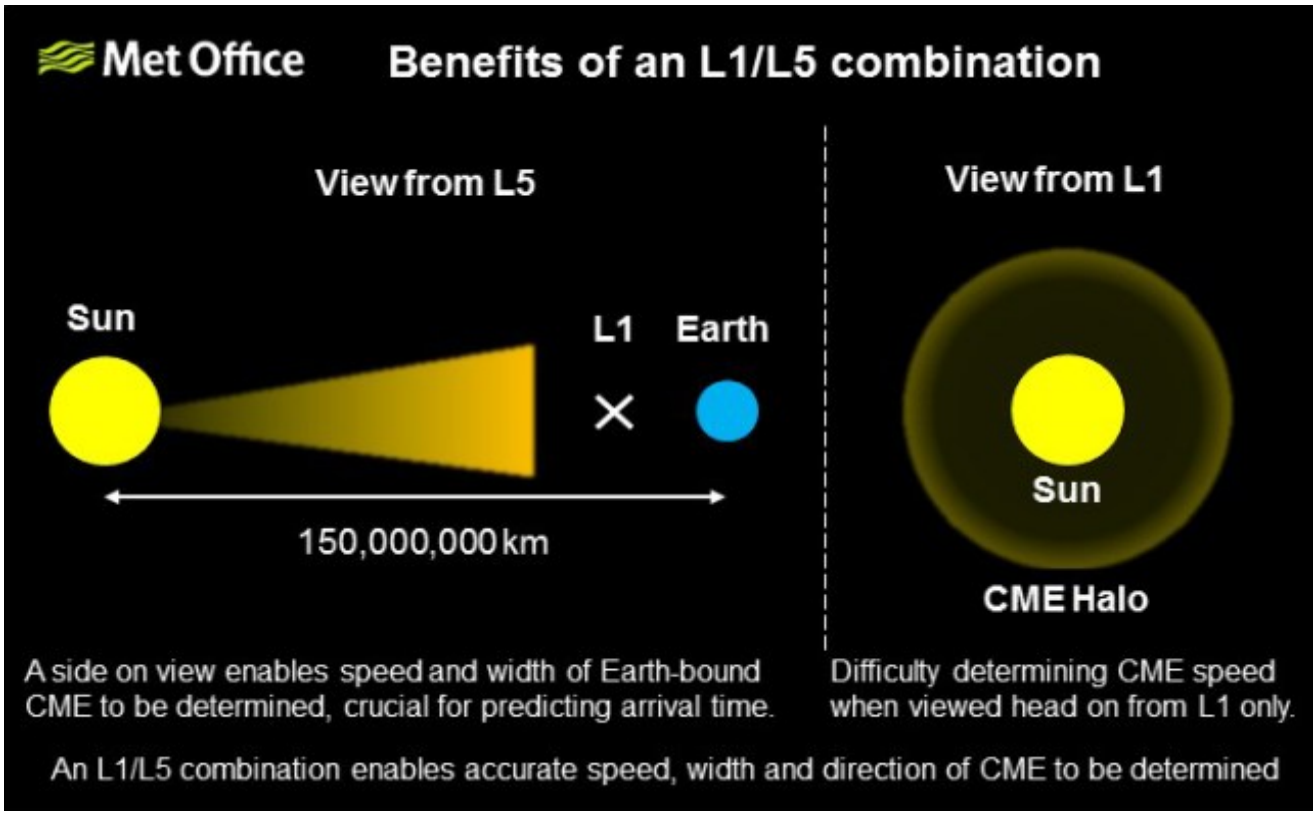
Vigil will provide a continuous side-on view of the gap between the Sun and the Earth, allowing forecasters to track and monitor coronal mass ejections (CMEs) with increased accuracy, as well as identify sunspot groups earlier, allowing key industry and infrastructure more time to take steps to mitigate any impacts.



L1 is the position of the existing satellite for space weather. L5 would provide a new perspective for tracking the Sun's activity.

Mark Gibbs, who leads the Met Office Space Weather Operations Centre, said: "A formal agreement for the Vigil mission for ESA is a huge step forward for our space weather forecasting capability. As one of a handful of 24/7 space weather forecasting centres in the world, this new satellite mission will replace an aging monitoring mission helping us improve our forecasting capability for space weather events and further deepen our scientific understanding of CMEs that generate geomagnetic storms.

"A side-on view of the Sun will provide us with more advanced and reliable data to monitor CMEs, improving our ability to forecast the arrival of these, potentially high impact events, at the Earth. We're looking forward to continuing to work with ESA on the mission and the data it will produce to ensure there's as much benefit as possible to both ourselves, but also international forecasting partners, to help mitigate the impacts of space weather."


Met Office
Benefits of an L1/L5 combination
View from L5
View from L1
Sun
L1
Earth
150,000,000 km
Sun
CME Halo
A side on view enables speed and width of Earth-bound CME to be determined, crucial for predicting arrival time.
Difficulty determining CME speed when viewed head on from L1 only.
An L1/L5 combination enables accurate speed, width and direction of CME to be determined

L1 is the position of the existing satellite for space weather. L5 will provide a new side-on perspective.

Impactful space weather has the potential to affect everyone and is a medium-high risk on the UK's National Risk Register. The ability to forecast these events can help mitigate the worst impacts to infrastructure.

The European Space Agency will manage the mission development and launch, which will take place at the end of this decade and will revolutionise the imagery and data available to space weather forecasters.

The announcements also included a boost for the earth observation sector.

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November 2022

Get ClimateReady – Climate change, cities and flooding

Description

Throughout November, we have been exploring the climate theme of cities – looking at the ways that cities could be impacted by climate change and learning about some of the research that is being undertaken to better understand and quantify these impacts.

As global warming continues, we are seeing increasing occurrences of weather extremes as a result of human-induced climate change. In a previous blog post, we explored the increasing frequency of extreme heat events and the way this heat is compounded in cities due to the nature of a typical urban landscape. Higher temperatures are not the only extreme that can be linked to climate change, however. As the planet warms, we can expect to see an increase in intense rainfall events and consequent flooding.

Flooding on the Thames

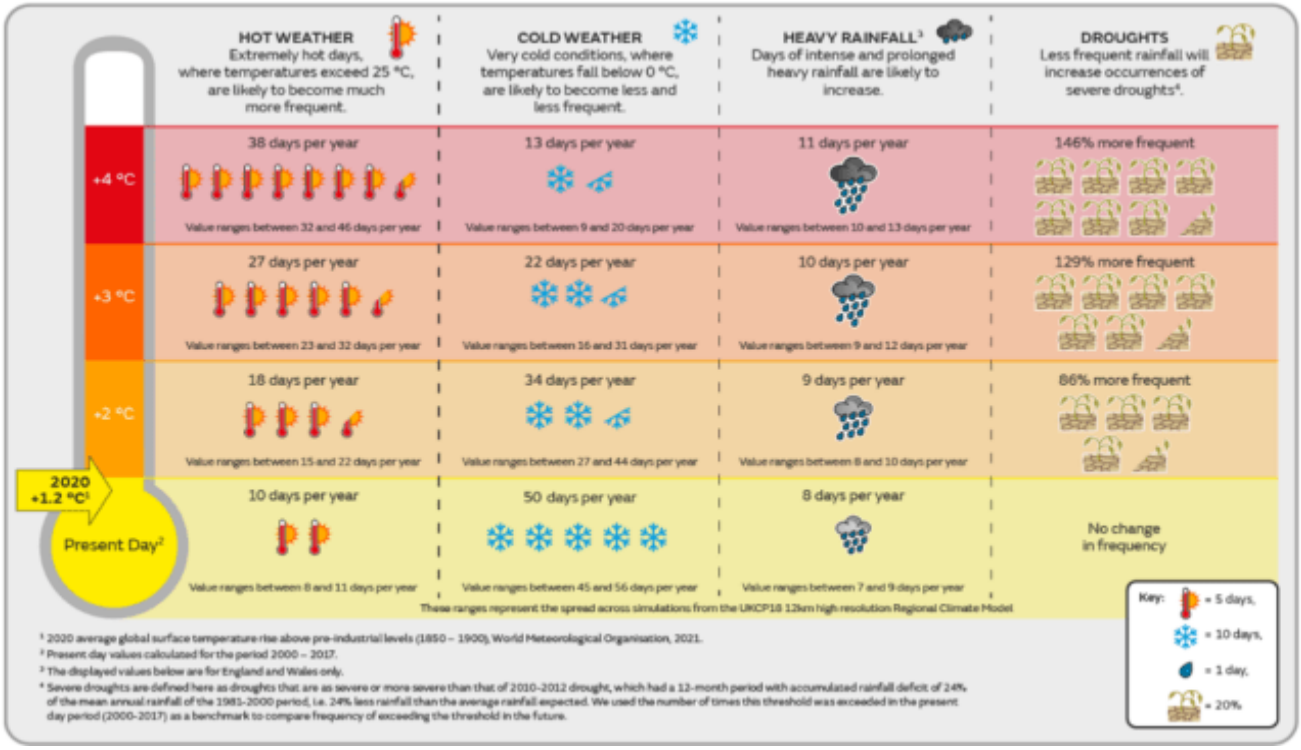
Some areas are more vulnerable to flooding than others, and cities can be particularly at risk of flash flooding. In this blog post we'll look into why this is and explore some of the research being carried out to better predict future changes in flooding in the city of Bristol.

Is the UK getting more rain?

The Met Office State of the UK Climate report for 2021 was published by the Royal Meteorological Society in July 2022. The report highlighted the evidence that the UK's climate is already changing, with recent decades warmer, wetter and sunnier than the 20th century. For rainfall, the most recent decade was 2% wetter than 1991-2020 and 10% wetter than the 1961-1990 period. Recent trends in

local rainfall extremes have also been detected, with some evidence that these are already being influenced by climate change (Cotterill et al 2021).

In another piece of research from the UK Climate Resilience (UKCR) Programme, researchers examined how different levels of global warming could affect the number of 'high-impact' weather days that we see in the UK. They found a positive correlation between increased global warming and instances of high-impact days, with projections indicating an increase of three days per year for high-impact heavy rainfall days under a high emissions (+4?) scenario.


HOT WEATHER
Extremely hot days, where temperatures exceed 25 °C, are likely to become much more frequent.
COLD WEATHER
Very cold conditions, where temperatures fall below 0 °C, are likely to become less and less frequent.
HEAVY RAINFALL[3]
Days of intense and prolonged heavy rainfall are likely to increase.
DROUGHTS
Less frequent rainfall will increase occurrences of severe droughts[4].
+4 °C
38 days per year
Value ranges between 32 and 46 days per year
13 days per year
Value ranges between 9 and 20 days per year
11 days per year
Value ranges between 10 and 13 days per year
146% more frequent
+3 °C
27 days per year
Value ranges between 23 and 32 days per year
22 days per year
Value ranges between 16 and 31 days per year
10 days per year
Value ranges between 9 and 12 days per year
129% more frequent
+2 °C
18 days per year
Value ranges between 15 and 22 days per year
34 days per year
Value ranges between 27 and 44 days per year
9 days per year
Value ranges between 8 and 10 days per year
86% more frequent
2020 +1.2 °C[1]
Present Day[2]
10 days per year
Value ranges between 8 and 11 days per year
50 days per year
Value ranges between 45 and 56 days per year
8 days per year
Value ranges between 7 and 9 days per year
No change in frequency
These ranges represent the spread across simulations from the UKCP18 12km high resolution Regional Climate Model
Key: = 5 days, = 10 days, = 1 day, = 20%
[1] 2020 average global surface temperature rise above pre-industrial levels (1850 – 1900), World Meteorological Organisation, 2021.
[2] Present day values calculated for the period 2000 – 2017.
[3] The displayed values below are for England and Wales only.
[4] Severe droughts are defined here as droughts that are as severe or more severe than that of 2010-2012 drought, which had a 12-month period with accumulated rainfall deficit of 24% of the mean annual rainfall of the 1981-2000 period, i.e. 24% less rainfall than the average rainfall expected. We used the number of times this threshold was exceeded in the present day period (2000-2017) as a benchmark to compare frequency of exceeding the threshold in the future.

Cities and heavy rainfall

Cities are particularly vulnerable to surface water flooding due to the nature of the terrain in urban areas. Pavements and tarmacked road surfaces are impermeable, meaning that rainwater cannot pass through and instead accumulates on the surface and eventually runs off. By contrast in rural areas rainfall is able to penetrate into the ground, reducing the risk of surface water flooding. Cities therefore require adaptive capacity (such as sustainable urban drainage systems), informed by the latest climate research and observational data, in order to minimise these risks.

Modelling flooding events to predict their severity

In a recent study led by Bristol University in collaboration with the Met Office as part of the UKCR Programme, researchers input UKCP local (2.2km) rainfall data directly into a flood impacts model to predict future flood risk. UKCP local simulations operate at a higher resolution of 2.2km, meaning they can more explicitly represent convective storms and provide improved estimates of hourly rainfall extremes. They also better capture local surface features such as cities, mountains and coastlines. The study found that using UKCP local data as opposed to the standard uplift approach* to drive

the LISFLOOD-FP flood inundation model, led to very different predictions of flood areas and depths for the Bristol metropolitan area. In particular, future changes in flood extent are higher when using the full UKCP local data.

The study highlighted the fact that the 1 in 30-year flood event does not simply correspond to the 1 in 30-year rainfall event (assumed in standard uplift approaches), since the degree of flooding is controlled by the complex interactions between the rainfall and the landscape (in this case the city environment). Also, the detailed variation of rainfall in space and time, and how this changes in the future, is important for future changes in flooding. On including the temporal and spatial interaction of the rainfall with the landscape, researchers achieved significantly different flood hazard estimates, when compared to using the standard approach.

Professor in Faculty of Science at Bristol University, Scientific Manager and Met Office Science Fellow, Professor Lizzie Kendon, who led on the research, said: “The climate is already changing – and we are starting to see this in observations here in the UK.

“Moving into the future the character of rainfall is expected to change with more intermittent but heavier rainfall. This could have devastating consequences for our cities that are particularly vulnerable to flash flooding. Existing drainage systems have been designed based on historically lower rainfall intensities and do not have the capacity for the projected increases in rainfall. Therefore, it is vitally important that we understand potential increases in flooding, so that we can make informed adaptation decisions.”

With climate projections indicating a future increase in the occurrence of heavy rainfall events, research like this demonstrates the value of high-resolution local data to ascertain the level of flood risk for a particular area. This enhanced understanding of flood risk enables informed decision-making when considering climate adaptation in UK cities.

If you would like to learn more about the flood risk where you live and how you can prepare for high-impact weather, visit our seasonal advice pages.

**** The standard uplift approach*** *refers to the more traditional approach of inputting observational rainfall data, to which a standard uplift (percentage increase in rainfall for a given return level, based on climate model output) has been applied, into a hydrological model to generate flood projections.*

Date Created
November 2022

How cities can become climate resilient

Description

Climate change is a major global challenge, and is already having a noticeable impact in the UK with the summer of 2022 being one of the hottest and driest on record.

During the rest of this century and beyond, projections indicate the UK will experience warmer and wetter winters, hotter and drier summers, and more frequent and intense weather extremes, such as heatwaves, droughts, flooding and storms.

Urban areas will be impacted more by these changes, because their populations are larger and denser than in rural areas, their road and building surfaces absorb and trap heat and are impermeable, and they have less green space.

The effects will include higher levels of heat stress and heat-related mortality, more transport network closures, power cuts, and higher repair bills.

Rescut teams in York City Centre after heavy rain led to significant flooding in December 2015

In addition to cutting emissions to reduce the level of global warming, people will need to adapt their ways of living to limit the impacts on themselves and those around them.

As part of the UK Climate Resilience Programme, the Met Office has been working with various local authorities across the UK to raise awareness and understanding of climate risks faced in those cities, and to help inform their climate resilience strategies.

The Urban Climate Services Team have used the latest UK Climate Projections data to provide high-level, non-technical summaries of climate change projections tailored specifically for each city or urban area.

Clifton Suspension Bridge and the surrounding area in Bristol

The first City Pack was co-developed with Bristol City Council. It contained factsheets explaining how the city's climate has changed and will continue to change, based on climate projections. The council have since used the climate information to inform their climate change risk assessment and climate strategy. It has also been used to engage with stakeholders, and as a communications and training tool.

The latest versions of the City Packs were published in August 2022 to help 20 UK cities and urban areas plan for the future and become more resilient to climate change. The initiative continues to expand in the UK and has begun in China.

An aerial shot of Manchester

Paul O’Hare, Senior Lecturer in Urban Geography & Development at Manchester Metropolitan University, has worked as an embedded researcher with Manchester Climate Change Agency on the city’s climate change framework.

He said: “Scientists have painstakingly researched the impacts that a warming world will have on our future climate. But it’s difficult to navigate through the detailed and complex outputs of climate projections, and present findings in a meaningful and useable way at a local level.

“The City Packs bring this scientific endeavour into the realm of city policy making and practice. They strike a neat balance between being engaging and scientifically rigorous, leaving users confident in their credibility and usefulness.

“The resources are vital in helping local authorities to identify and communicate key messages about the impacts of climate change both now and in the future. They also help them to develop their own climate plans and policies for the benefit of local people, businesses and visitors.”

Richard McLernon is the Climate Programme Manager at Belfast City Council. He said the Belfast City Pack had been a “valuable resource” for the council to brief the Belfast Resilience and Sustainability Board, who oversee the city’s plans to address city resilience and climate planning.

Richard added: “We found the City Pack complimented the Belfast Climate Risk Assessment which identified the climate risks facing the city, and the work undertaken together on the resource has created an important relationship with the Met Office which has been a great benefit to the city.”

As extreme events – such as the very hot and dry summers of 2018 and 2022 and the summer 2007 floods, become normal by 2050 – the Met Office will continue helping urban areas to become climate resilient. By providing them with the latest climate projections, scientists can help local authorities to

characterise and quantify climate risks, produce adaptation strategies, and turn information and knowledge into action.

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